CLAIMS

We claim:

1. A computer-readable medium encoded with computer-executable instructions for causing a computer programmed thereby to perform a method of
5   controlling quality of information in a constant bitrate encoder, wherein the encoder outputs the information at variable quality and compressed to a constant or relatively constant bitrate, the method comprising:

quantizing a block of information to meet constant or relatively constant bitrate requirements, wherein the encoder adjusts quantization step size of the quantizing in
10   view of a target quality parameter for the block, thereby reducing number of changes in quality and smoothing transitions between the changes in quality; and

entropy coding the quantized block of information.

2. The computer-readable medium of claim 1 wherein the encoder adjusts the
15   quantization step size also in view of a target minimum-bits parameter and a target maximum-bits parameter.

3. The computer-readable medium of claim 1 wherein the encoder adjusts the quantization step size also in view of one or more complexity estimates and one or
20   more complexity estimate noise measures.

4. The computer-readable medium of claim 1 wherein the block has a block size selected from among plural available block sizes, wherein the encoder adjusts the quantization step size also in view of a value of control parameter for the block, and
25   wherein the encoder normalizes block size when computing the value.

5. The computer-readable medium of claim 1 wherein the encoder adjusts the quantization step size in a quality control quantization loop and in a bit-count control quantization loop following and de-linked from the quality control quantization loop.

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6. The computer-readable medium of claim 5 wherein the encoder adjusts the quantization step size by different rules in the quality control quantization loop and the bit-count control quantization loop.

5   7. The computer-readable medium of claim 1 wherein the encoder accounts for non-monotonicity of quality as a function of quantization step size when the encoder adjusts the quantization step size.

8. The computer-readable medium of claim 1 wherein the encoder adjusts the
10   quantization step size also in view of a value of control parameter for the block, and wherein the encoder lowpass filters the value as part of a series of values.

9. The computer-readable medium of claim 1 wherein the encoder adjusts the quantization step size also in view of a value of control parameter for the block, and
15   wherein the encoder computes the value to correct bias in a model that relates quality and bitrate or bit count to quantization step size.

10. In an audio encoder, a computer-implemented method comprising:
        compressing a block of frequency coefficients, wherein the compressing
20   includes,
                quantizing the block of frequency coefficients;
                comparing a quality measure for the block to a quality target;
                comparing a bit-count measure for the block to a minimum-bits target
        and to a maximum-bits target.
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11. The method of claim 10 wherein the compressing further includes:
        computing the quality measure based upon the quantized block of frequency
coefficients;
        entropy encoding the quantized block of frequency coefficients; and
30   computing the bit-count measure based upon the entropy encoded block of
frequency coefficients.

12. The method of claim 10 wherein a first quantization loop includes the quantizing and the comparing the quality measure, and wherein a second quantization loop de-linked from the first quantization loop includes the comparing the bit-count measure.

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13. The method of claim 10 wherein the quality target, the minimum-bits target, and the maximum-bits target are for the block.

14. A computer-readable medium encoded with computer-executable

10   instructions for causing a computer programmed thereby to perform a method of controlling quality and bitrate in an audio encoder, the method comprising:

determining one or more target quality parameters, a first target quality parameter of the one or more target quality parameters indicating an acceptable audio quality;

15   determining plural target bitrate parameters, a first target bitrate parameter of the plural target bitrate parameters indicating a minimum acceptable number of bits produced, and a second target bitrate parameter of the plural target bitrate parameters indicating a maximum acceptable number of bits produced;

compressing audio information, wherein quantization of the audio information is

20   based at least in part upon the first target quality parameter, the first target bitrate parameter, and the second target bitrate parameter.

15. The computer-readable medium of claim 14 wherein the audio information is a block of frequency coefficients.

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16. The computer-readable medium of claim 15 wherein the first target quality parameter, the first target bitrate parameter, and the second target bitrate parameter are for the block.

30   17. The computer-readable medium of claim 14 wherein the compressing includes:

quantizing the audio information;

computing a quality measure based upon the quantized audio information; and

comparing the quality measure to the first target quality parameter.

18. The computer-readable medium of claim 14 wherein the compressing
includes:

quantizing the audio information;

entropy encoding the quantized audio information;

computing a bit-count measure based upon the entropy encoded audio
information; and

comparing the bit-count measure to the first and second target bitrate
parameters.

19. The computer-readable medium of claim 14 wherein the compressing
includes:

in a first quantization loop, adjusting the quantization until satisfaction of the first
target quality parameter; and

in a second quantization loop, adjusting the quantization until satisfaction of the
first and second target bitrate parameters.

20. The computer-readable medium of claim 14 wherein the first target bitrate
parameter is a function of factors comprising an average bit count estimate, buffer
fullness, and buffer sweet spot.

21. The computer-readable medium of claim 14 wherein the second target
bitrate parameter is a function of factors comprising an average bit count estimate,
buffer fullness, and buffer sweet spot.

22. The computer-readable medium of claim 14 wherein the first target quality
parameter is a function of factors comprising a complexity estimate and goal bit count.

23. The computer-readable medium of claim 22 wherein the complexity
estimate is a composite of a past complexity estimate and a future complexity estimate.

24. The computer-readable medium of claim 22 wherein the complexity estimate is based at least in part upon a complexity estimate reliability measure.

5   25. The computer-readable medium of claim 22 wherein the audio information is a block of frequency coefficients, and wherein the goal bit count is based at least in part upon size of the block and maximum block size

26. In an audio encoder, a computer-implemented method comprising:
10   computing a value of a control parameter for a block of spectral audio information, wherein the control parameter is based at least in part upon one or more complexity estimate noise measures; and

quantizing the block, wherein the value of the control parameter at least in part regulates the quantizing.
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27. The method of claim 26 wherein a first measure of the one or more complexity estimate noise measures indicates reliability of complexity estimation for one or more future blocks of spectral audio information.

20   28. The method of claim 26 wherein a first measure of the one or more complexity estimate noise measures indicates reliability of complexity estimation for one or more past blocks of spectral audio information.

29. The method of claim 26 wherein a first measure of the one or more complexity estimate noise measures indicates reliability of complexity estimation for
25 one or more future blocks of spectral audio information, and wherein a second measure of the one or more complexity estimate noise measures indicates reliability of complexity estimation for one or more past blocks of spectral audio information.

30   30. The method of claim 26 wherein the control parameter is a target quality parameter.

31. The method of claim 26 wherein each of the one or more complexity estimate noise measures affects weight given to a corresponding complexity estimate in the computing the value of the control parameter.

5   32. The method of claim 26 further comprising:

computing the one or more complexity estimate noise measures, including computing a first measure of noise in a first complexity estimate.

33. The method of claim 32 wherein the computing the one or more complexity
10   estimate noise measures further includes lowpass filtering the first measure as part of a sequence.

34. A computer-readable medium encoded with computer-executable instructions for causing a computer programmed thereby to perform the method of
15   claim 26.

35. An audio encoder comprising:

means for computing a value of a control parameter for audio information, wherein the control parameter is based at least in part upon one or more reliability
20   measures for complexity estimates; and

a quantizer for quantizing the audio information, wherein the value of the control parameter at least in part regulates the quantizer.

36. The audio encoder of claim 35 further comprising:
25   means for computing the one or more reliability measures based upon noise in the complexity estimates.

37. The audio encoder of claim 35 wherein the complexity estimates include past complexity estimates, the encoder further comprising:
30   a past complexity estimator for computing the past complexity estimates.

38. The audio encoder of claim 35 wherein the complexity estimates include future complexity estimates, the encoder further comprising:

a future complexity estimator for computing the future complexity estimates.

5   39. The audio encoder of claim 35 wherein the complexity estimates include past complexity estimates and future complexity estimates, the encoder further comprising:

a past complexity estimator for computing the past complexity estimates; and

a future complexity estimator for computing the future complexity estimates.

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40. A computer-readable medium having encoded therein computer-executable instructions for causing a computer programmed thereby to perform a method of regulating output of an audio encoder, the audio encoder processing plural blocks of audio information, wherein each of the plural blocks has one of plural

15   available block sizes, the method comprising:

for each of the plural blocks of audio information,

computing one or more values of control parameters, wherein the computing includes normalizing block size for the block; and

quantizing the block, wherein the one or more values of control

20   parameters at least in part regulate the quantizing.

41. The computer-readable medium of claim 40 wherein the normalizing includes:

determining the block size of the block; and

25   computing ratio of the block size to a maximum block size, wherein the one or more values of control parameters are based at least in part upon the ratio.

42. The computer-readable medium of claim 40 wherein the one or more control parameters include a target quality measure.

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43. The computer-readable medium of claim 40 wherein the one or more control parameters are selected from the group consisting of goal bit count and past complexity estimate.

5   44. The computer-readable medium of claim 40 wherein the plural blocks of audio information comprise plural transform blocks of frequency coefficients.

45. An audio encoder comprising:

a frequency transformer for transforming a time domain block of audio samples

10   into a transform block of frequency coefficients, wherein the transform block has a transform block size selected from among plural available transform block sizes;

means for computing a value of a control parameter, wherein the computing includes normalizing transform block size for the transform block; and

a quantizer for quantizing the transform block, wherein the value of the control

15   parameter at least in part regulates the quantizing.

46. The encoder of claim 45 wherein the normalizing includes:

determining the transform block size of the transform block; and

computing ratio of the transform block size to a maximum transform block size,

20   wherein the value of the control parameter is based at least in part upon the ratio.

47. The encoder of claim 45 wherein the control parameter is a goal bit count.

48. The encoder of claim 45 wherein the control parameter is a past complexity

25   estimate.

49. The encoder of claim 45 wherein the control parameter is a target quality measure.

30   50. The encoder of claim 45 wherein the frequency transformer applies a modulated lapped transform.

51. A computer-readable medium encoded with computer-executable
instructions for causing a computer programmed thereby to perform a method
comprising:

adjusting quantization of a block of frequency coefficients for audio information
5   in a quality control quantization loop until satisfaction of one or more quality criteria;
and

following and outside the quality control quantization loop, adjusting the
quantization of the block in a bitrate control quantization loop until satisfaction of one or
more bitrate criteria.

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52. The computer-readable medium of claim 51 wherein the bitrate control
quantization loop exits if the block satisfies the one or more bitrate criteria.

53. The computer-readable medium of claim 51 wherein the bitrate control
15   quantization loop exits before the adjusting the quantization if the block satisfies the
one or more bitrate criteria after the quality control quantization loop.

54. The computer-readable medium of claim 51 wherein if simultaneous
satisfaction of the bitrate and quality criteria is not achieved, the satisfaction of the one
20   or more bitrate criteria causes failure of the one or more quality criteria.

55. The computer-readable medium of claim 51 wherein the one or more
quality criteria include a target quality, and wherein the one or more bitrate criteria
include a target minimum bit count and a target maximum bit count.

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56. In an audio encoder, a computer-implemented method of controlling bitrate
and audio quality, the method comprising:

in each of one or more iterations of a first quantization loop,

quantizing audio information;

30   measuring audio quality ;

comparing the measured audio quality to one or more target quality
parameters;

in each of one or more iterations of a second quantization loop following and
outside of the first quantization loop,

     measuring bit count of the audio information; and

     comparing the measured bit count to one or more target bit count

5   parameters.

    57. The method of claim 56 wherein the audio information is a block of
frequency coefficients.

10   58. The method of claim 57 wherein the one or more target quality parameters
and the one or more target bit count parameters are for the block.

    59. The method of claim 56 further comprising:

    in each of the one or more iterations of the second quantization loop. entropy

15   encoding the block of audio information.

    60. The method of claim 56 further comprising:

    in each of one or more iterations after a first iteration of the second quantization
loop, adjusting quantization level and re-quantizing the block of audio information.

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    61. The method of claim 56 further comprising:

    after the comparing the measured audio quality, exiting the first quantization
loop if the measured audio quality satisfies the one or more target quality parameters.

25   62. The method of claim 56 further comprising:

    after the comparing the measured bit count, exiting the second quantization
loop if the measured bit count satisfies the one or more target bit count parameters.

    63. The method of claim 56 wherein the one or more target bit count

30   parameters include a target minimum bit count parameter and a target maximum bit
count parameter.

64. A computer-readable medium encoded with computer-executable instructions for causing a computer programmed thereby to perform the method of claim 56.

5   65. A computer-readable medium encoded with computer-executable instructions for causing a computer programmed thereby to perform a method comprising:

        selecting a quantization level within a range of quantization levels, wherein the selecting accounts for non-monotonicity of quality measure as a function of
10   quantization level within the range; and

        quantizing audio information by the quantization level.

        66. The computer-readable medium of claim 65 wherein the audio information is a block of frequency coefficients, and wherein the quantization level is a quantization
15   step size.

        67. The computer-readable medium of claim 65 further comprising:

        computing a first quality measure indicating quality of the audio information as quantized by the quantization level;
20   comparing the first quality measure to a second quality measure for the audio information, the second quality measure indicating quality of the audio information as quantized by a previous quantization level higher than the quantization level; and

        if the first quality measure indicates worse quality than the second quantization level, designating the quantization level as inferior.
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        68. The computer-readable medium of claim 65 further comprising:

        computing a first quality measure indicating quality of the audio information as quantized by the quantization level;

        recording the quantization level and the first quality measure in a trajectory
30   point array.

        69. The method of claim 65 wherein the selecting comprises:

if the function is non-monotonic, selecting the quantization level in a first mode, and otherwise, selecting the quantization level in a mode other than the first mode.

70. A computer-readable medium encoded with computer-executable
5   instructions for causing a computer programmed thereby to perform a method comprising:

quantizing audio information by a quantization level;

computing a first quality measure indicating quality of the audio information as quantized by the quantization level;

10   comparing the first quality measure to a second quality measure for the audio information, the second quality measure indicating quality of the audio information as quantized by a previous quantization level; and

if the comparing indicates non-monotonicity of quality measure as a function of quantization level, designating the quantization level as inferior.

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71. The computer-readable medium of claim 70 wherein the audio information is a block of frequency coefficients, and wherein the quantization level is a quantization step size.

20   72. The computer-readable medium of claim 70 further comprising:

recording the quantization level and the first quality measure in a trajectory point array.

73. In an audio encoder, a computer-implemented method comprising:
25   determining a first bit count associated with a first quantization level;

determining a second bit count associated with a second quantization level;

determining a third quantization level within a quantization level range based upon location of a target bitrate on a trajectory of bit count as a function of quantization level, wherein the first and second quantization levels define endpoints of the
30   quantization level range, wherein the first and second bit counts define endpoints of the trajectory, and wherein the function relates bit count in proportion to inverse logarithm of quantization level.

74. In an audio encoder, a computer-implemented method comprising:

determining a first quality measure associated with a first quantization level;

determining a second quality measure associated with a second quantization

5   level;

determining a third quantization level within a quantization level range based upon location of a target quality on a trajectory of quality measure as a function of quantization level, wherein the first and second quantization levels define endpoints of the quantization level range, wherein the first and second quality measures define

10   endpoints of the trajectory, and wherein the function relates logarithm of quality measure in proportion to inverse logarithm of quantization level.

75. In an audio encoder, a computer-implemented method comprising:

in a quality control quantization loop iteration, selecting a first uniform, scalar

15   quantization step size using a first set of rules and quantizing audio information using the first uniform, scalar quantization step size; and

in a bit-count control quantization loop iteration, selecting a second uniform, scalar quantization step size using a second set of rules and quantizing the audio information using the second uniform, scalar quantization step size, wherein the

20   second set of rules is different than the first set of rules.

76. A computer-readable medium encoded with computer-executable instructions for causing a computer programmed thereby to perform a method comprising:

25   computing a value of a control parameter for a block of audio information; and

filtering the value as part of a sequence of previously computed values of the control parameter, wherein the filtered value of the control parameter is for regulating at least in part quantization of the block of audio information.

30   77. The computer-readable medium of claim 76 wherein the control parameter maps a composite strength estimate to a complexity estimate.

78. The computer-readable medium of claim 76 wherein the control parameter is a complexity estimate for one or more past blocks of audio information.

79. The computer-readable medium of claim 76 wherein the control parameter
5   is a complexity estimate noise measure.

80. The computer-readable medium of claim 76 wherein the filtering comprises lowpass filtering.

10   81. The computer-readable medium of claim 80 further comprising:
adjusting bandwidth of the lowpass filtering to regulate smoothness of quality changes between blocks of audio information.

82. The computer-readable medium of claim 81 wherein the adjusting is based
15   at least in part upon current buffer fullness.

83. The computer-readable medium of claim 81 wherein the adjusting is based at least in part upon encoder settings.

20   84. An audio encoder comprising:
means for computing a value of a control parameter for audio information;
a filter for lowpass filtering the value as part of a sequence of previously computed values for the control parameter; and
a quantizer for quantizing the audio information, wherein the filtered value of the
25   control parameter at least in part regulates the quantizer.

85. The encoder of claim 84 wherein the audio information is a block of frequency coefficients, the encoder further comprising:
a frequency transformer for transforming a time domain block of audio samples
30   into the block of frequency coefficients.

86. The encoder of claim 84 wherein the control parameter maps a composite strength estimate to a complexity estimate.

87. The encoder of claim 84 wherein the control parameter is a complexity
5   estimate.

88. The encoder of claim 84 wherein the control parameter is a complexity estimate noise measure.

10   89. The encoder of claim 84 wherein the filter has a bandwidth, and wherein the encoder adjusts the bandwidth to regulate smoothness of quality changes.

90. The encoder of claim 89 further comprising:
a virtual buffer, wherein the bandwidth is based at least in part upon current
15   fullness of the virtual buffer.

91. A computer-readable medium encoded with computer-executable instructions for causing a computer programmed thereby to perform a method comprising:
20   comparing a desired buffer fullness level to a current buffer fullness level;
        correcting bias in a model by adjusting a value of a control parameter for a block of audio information based at least in part upon a result of the comparing, wherein the adjusted value of the control parameter is for regulating at least in part quantization of a subsequent block of audio information.
25

92. The computer-readable medium of claim 91 wherein the block of audio information is a transform block of frequency coefficients, and wherein the desired buffer fullness level and the current buffer fullness level indicate levels of a virtual buffer.
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93. The computer-readable medium of claim 91 wherein the adjusting is also based at least in part upon an achieved bit count for the block and a header bit count for the block.

5   94. The computer-readable medium of claim 91 wherein the control parameter is an achieved bit count for the block.

95. The computer-readable medium of claim 91 wherein the correcting affects an achieved bit count for the subsequent block, thereby making a subsequent buffer

10   fullness level closer to the desired buffer fullness level.

96. An audio encoder comprising:
a virtual buffer for storing bits for one or more blocks of frequency coefficients, the virtual buffer having a current fullness level and a desired fullness level; and

15   means for correcting model bias by adjusting a value of a control parameter based at least in part upon a result of comparing the desired fullness level to the current fullness level, wherein the adjusted value is for regulating at least in part subsequent quantization.

20   97. The encoder of claim 96 further comprising:
a quantizer for quantizing blocks of frequency coefficients.

98. The encoder of claim 96 wherein the control parameter is a bit count for a current block of frequency coefficients.

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99. The encoder of claim 96 wherein the adjusting is also based at least in part upon an achieved bit count for a current block of frequency coefficients and a header bit count for the current block of frequency coefficients.

30   100. The encoder of claim 96 wherein the correcting affects an achieved bit count for a subsequent block of frequency coefficients, thereby making a subsequent buffer fullness level closer to the desired buffer fullness level.